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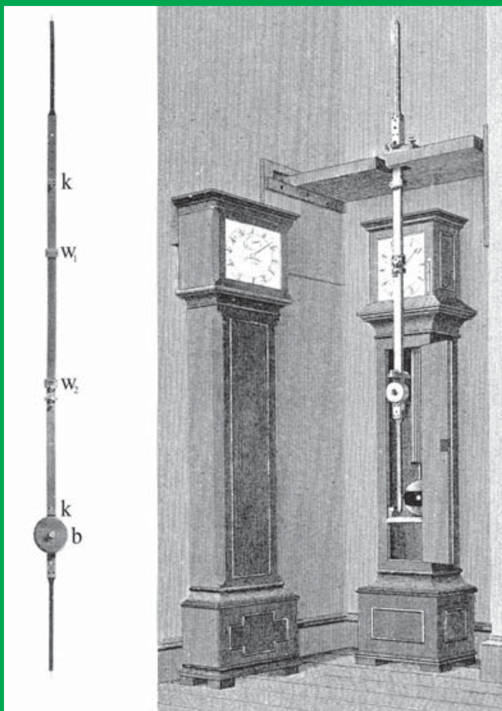

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EDITORIAL

GEOPHYSICS AND SIGNING-OFF

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As with my last editorial (*ESH* 26.1) I shall be brief as this issue of *Earth Sciences History* contains plenty of interesting reading that deserve your focus more than does this editorial preamble. The issue contains seven papers on the history of geophysics first presented at the International Commission on the History of Geological Sciences (INHIGEO) symposium held in Prague in July 2005. This meeting was organised by Jan Kozák, and the papers are published here following a request made to me by the organiser, and by David Oldroyd and Ken Bork, INHIGEO General Secretary. It is unnecessary for me to introduce the papers as this has been done by Messrs Kozák and Oldroyd (see pp. 195–199).

I am returning my green editorial pen to the drawer in my desk as this is the last issue of *Earth Sciences History* that I will have editorial responsibility for. I have enjoyed much of my time serving as Editor, although I am slightly relieved that I will not have to hand-pack journals for mailing again, nor will I have to persuade my students to carry boxes of freshly printed journals up three flights of stairs to my office! I also believe that the staff of the Mail Office in Trinity College will be happy to see the back of *Earth Sciences History*. It has been hugely enjoyable for me to read the offerings presented for possible publication in the journal, although it has for various reasons proved impossible to publish all submissions. I am grateful to all those authors who have contributed papers.

Earth Sciences History went through slight changes during my tenure—readers will now be familiar with the green front cover, and the Kircher logo that sits alongside the abstracts of papers. It also physically changed size as it was cheaper for my Irish-based printer to use Imperial-size paper rather than import US-size paper. However, I believe that subscribers continued to receive scholarly papers that provided advances in our understanding of many facets of the history of the earth sciences. It does not really matter what the journal looks like as long as the quality and robustness of the content is not compromised, although an attractive journal, that is easy to handle, is beneficial.

I have been greatly aided in my role as your Editor in the last three years by many people. I thank the Presidents of HESS, Martin Rudwick and his successor Naomi Oreskes, our Treasurers Ed Rogers, and latterly Emma Rainforth, who have always been very supportive, and Greg Good and Bill Brice who along with others have assisted me with wisdom along the editorial road. Gerry Friedman continued to supply his essential 'Interesting Publications', while Vic Baker has kept a stream of book reviews flowing to Dublin for publication. Without the expertise in various areas of the Associate Editors I would have been floundering. I am most grateful to you all. Thank you one and all, and thank you readers who have not complained at my efforts.

NOTEWORTHY NEWS

It is not usual for *Earth Sciences History* to carry items of recent news but it is not every day that a Past-President of the History of the Earth Sciences Society receives a major award. We warmly congratulate Martin Rudwick, the recipient of the Sarton Medal of the History of Sciences Society for 2007. This medal is given annually in recognition of a lifetime of scholarly achievement.

James Secord in his citation notes that ‘There can be no question that Martin has been the most influential historian of the earth sciences in the past fifty years’ and that he ‘has shaped the way we see some of the most widely discussed episodes in history of science, and has consistently set standards for analytical rigor, innovation, and depth of research. His writings have been at the forefront of our field for nearly four decades, and are models of appropriate use of visual arguments and engaging prose.’ [The full citation may be read at http://www.hssonline.org/about/society_awards2007.html.]

INTRODUCTION TO THEMATIC SET OF PAPERS ON THE HISTORY OF GEOPHYSICS

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The annual Symposium of the International Commission on the History of Geological Sciences (INHIGEO) for 2005 was held in Prague from 2 to 12 July, 2005, the conference theme being History of Geophysics. Selected contributions presented in this Symposium appear in the present issue of *Earth Sciences History* and are here submitted to readers. The intention has been to provide a set of papers that outline some of the more salient issues in the histories of the several branches of geophysics.

INHIGEO's meetings have traditionally been inclined in the direction of the study of "straight" geological topics. Therefore, before embarking upon the main papers in this issue on the history of geophysics and some of its sub-disciplines, a brief discussion of the terms *geology* and *geophysics* may be appropriate.

Unexpectedly, such definitions especially in relation to the words *geology* and *geological* are not easy to formulate without ambiguity, and in such a way that they can be commonly recognized, accepted, and defended. It seems there are two reasons for this. First, the field of research understood as *geology*, has in the course of the two last Centuries, been transformed in size and content through the new achievements in the study of the Earth, becoming enriched and broadened (but also narrowed for individual researchers) by the emergence of new disciplines and sub-disciplines. The second reason arises from the fact that many people, even today, take it that geology (*geo* + *logos*) or geognosy (*geo* + *gnosis*) encompass all branches of Earth science, *including* geophysics. In part, this can be understood as a relic of the situation in the nineteenth century when newer disciplines such as geophysics and geochemistry were not yet established; or if they were they were not widely recognized.

Even geophysicists were uncertain about their field. For example, if we could ask Georg Gerland (1833–1919) an enthusiastic promoter of geophysics and founding editor of *Beiträge für Geophysik* whether geothermics belonged among the geological or the geophysical disciplines, very likely he would very likely have said: "I can't say; I don't know that discipline"! By contrast, some geophysicists today may know little about important branches of geology.

Here we suggest that geology and geophysics, according to present understandings are two important, sometimes overlapping, disciplines in Earth science. They study the same subject, but according to different categories and using different tools. They may be defined as follows.

Geology: The study of the planet Earth the materials of which it is made, the processes that act on these materials, the products formed, and the history of the planet and its life-forms since its origin. Geology considers the physical forces that act on the Earth, the chemistry of its constituent materials, and the biology of its past inhabitants as revealed by fossils. . . . The knowledge thus obtained is placed in the service of man . . . (Bates and Jackson 1997, p. 258).

Geophysics: Study of the Earth by quantitative physical methods. Basic subdivisions include solid-earth geophysics, physics of the atmosphere and hydrosphere, and solar-terrestrial physics (Bates and Jackson 1997, p. 259).

or

Geology: The science which has for its object the investigation of the Earth's crust, of the strata which enter into its composition, with their mutual relations, and of the successive changes to which their present condition and positions are due. *Oxford English Dictionary online* (Oxford: Oxford University Press, 2000–).

Geophysics: The science or study of the physics of the Earth, esp. of its crust; the application of the principles, methods, and techniques of physics to the study of the Earth. *Oxford English Dictionary online* (Oxford: Oxford University Press, 2000–).

Other relevant definitions are:

Geoelectrics: The study of the Earth's natural electrical fields and associated phenomena.
Geomagnetics: The study of the Earth's magnetic properties and related phenomena.
Geothermics: The scientific study of the Earth's thermal properties.
Gravimetry: The scientific study of the Earth's gravitational field and its variations (used to determine the form of the Earth [geoid], geological structures, sub-surface variations of rock type, mineral prospecting).
Seismology: The scientific study of earthquakes, and their causes and effects and associated phenomena, leading also to an understanding of the Earth's internal structure, either deep or shallow.
Plate tectonics: The study of the past and present behavior of the Earth's lithosphere, which is regarded as being composed of a number of "plates." The mutual interactions of these plates, thought to be driven by convection currents within the Earth's interior, produce seismic and volcanic events and global tectonic activity.

Regarding the foregoing branches of geophysics, the following historical notes may be useful:

Geomagnetism

The first geomagnetic measurements and studies of the late eighteenth and the first half of the nineteenth century were stimulated by practical need of sea travel (more exact coordinate determination) and in cartography (more precise mapping), etc. The first world maps giving declination values and "isodynamical lines," were prepared by the sea captains of the above period. Only afterwards was pertinent "fundamental research" in the field started, with the establishment of geomagnetic observatories round the world. Such work was stimulated by the polymathic traveller, Alexander von Humboldt and the mathematician Carl Friedrich Gauss, who was interested in the mathematical problem of describing and analyzing the Earth's magnetic field.

Seismology

In this discipline, since obtaining reliable data was so difficult (seismometers did not appear before the 1880s), physical speculations about the Earth interior and on the physics of earthquake occurrences for long overshadowed practical (applied) questions. This was true up to the first half of the twentieth century; and even today fundamental seismological research is much more advanced than that related to specific applied tasks, such as earthquake prediction. As in geomagnetics, progress has depended on the establishment of networks of observatories and the co-ordination of observations, which enables ideas to be developed about the Earth's internal deep structure. Seismic instruments and techniques can also be applied in such fields as sequence stratigraphy.

Gravimetry

This field began as a part of basic physical research, which dominated before gravimetry became relevant to applied questions, since (by contrast with seismology) the applied questions were essentially simple and intelligible. It came into its own as a branch of geophysics with the rise of interest in isostasy, and subsequently played a large part in the development of tectonics. Large-scale gravimetric survey, as conducted by the US Coast and Geodetic Survey, and the study of the form of the Earth (determination of the geoid) was relevant to theories of the Earth in the first half of the twentieth century and to the plate-tectonics revolution. Gravimetry has also been highly relevant to mineral prospecting.

Geothermics

This was important in the early nineteenth century in the studies of the geothermal gradient, which gave support to the Vulcanist, as opposed to the Neptunist, theory of the Earth. Subsequently geothermic studies have been applied in studying structural geology and tectonics, and the heat generated by radioactive decay is an essential feature for understanding the Earth's long-term history and its inner workings (convection currents). Geothermal energy has applications in some countries, and has possibilities for extended use by extraction of heat from "hot rock."

Geoelectrics

Mapping of resistivities can be a useful tool for studying the Earth's internal structure (electrical tomography) and for mineral prospecting. Geoelectrics also has applications in archeology and in stratigraphic correlation (when the geoelectrical properties of rocks in neighbouring bore-holes are compared).

Historically, we may compare geology and geophysics as follows:

Geology	*Geophysics*
Beginnings	**Beginnings**
Descartes, Hooke, Steno, Lister, Leibniz (seventeenth century)	Halley (geomagnetism)
Lehmann, Pallas, Dolomieu, de Saussure, Werner (eighteenth century)	Michell (Lisbon earthquake study) Franklin (“geoelectrics”) Michell, Cavendish (gravimetry)
As a scientific discipline	**As a scientific discipline**
Hutton, de Luc (eighteenth century)	
Smith, Cuvier, von Buch (early nineteenth century)	von Humboldt, Gauss (geomagnetism) Cordier (geothermics)
Lyell, Elie de Beaumont, Sedgwick, Murchison, Agassiz, Dana, Oppel, d’Orbigny, Hall, Daubrée (mid-nineteenth century)	Hopkins, Volger, Mallet (seismology)
Suess, Zirkel, Powell, Michel Levy, Dutton, Gilbert, Davis, Walcott, Fouqué, Chamberlin, Richthofen, Rosenbusch, Heim, Lapworth, Barrande, Karpinskii, Dana (second half of the nineteenth century)	Schuster, von Neumayer (geomagnetism) Milne, Suess, Wiechert, Omori (seismology) Fourier, Kelvin (geothermics) Airy, Pratt, Dutton, US geodetic survey (gravimetry)
Object of study	**Object of study**
Earth’s surface; later the Earth’s crust. The Earth’s history and age determinations (absolute or relative)	The whole body of the Earth, including its interior, its surrounding hydrosphere and the atmosphere
Tools of study (historical)	**Tools of study (historical)**
Visual observation (hand-lens, clinometer, hammer); later microscopic and chemical analyses for study of classification and distribution of rocks, strata, etc. Use of fossils for stratigraphic correlation. Type specimens. Mapping.	Quantitative measurements of physical parameters (geomagnetism, gravity, heat, mechanical and dynamic rock parameters, electric fields) by specially developed instruments such as seismographs, magneto-meters, electrometers, gravimeters, electro-scopes, etc. Determination of physical fields of force.
Tools of study (modern)	**Tools of study (modern)**
As before, plus modern geological techniques. Specialized maps (e.g. tectonic, economic). Statistical analysis of data. Large data-bases. Aerial surveys and photography. Ecology, geochemical analyses, experimental petrology, experimental sedimentology, oceanographic exploration, etc. Isotopic ratio studies.	All kinds of advanced physical and geophysical methods and instruments, assisted by computers for modelling and data-storage
Earth’s rates of change and tectonic stresses/forces acting	**Earth’s rates of change and tectonic stresses/forces acting**
Lyell and uniformitarians: slow through whole of Earth history; crustal movements chiefly vertical	Historically: slow, fast, or super-fast
Present-day: rapid as well as slow changes; lateral as well as vertical forces and movements	Present-day: as before
Volcanology	
Can be regarded as either a geological or a geophysical science, or an independent science with characteristics of both	

Geology was, of course, an established science well before geophysical work proper began in the 1830s. (Eighteenth-century gravimetry was more concerned with physics and astronomy than with the study of the Earth "for its own sake.") The newer geophysical disciplines came to be supported by wider and more secure geological and physical knowledge on the one hand and by the new measuring instruments and techniques of the nineteenth and twentieth centuries. While geology examined the Earth's strata, rocks, fossils, etc., building up a stock of knowledge collected by travellers and makers of geological maps, geophysics assembled data about the behaviour of the planet using specially designed instruments at specially constructed observation stations, or by portable instruments. The analysis and comparison of data at different stations made possible inferences about the Earth's internal constitution and behavior. Thus geophysicists sought to "look" below the Earth's surface into its interior, whereas geologists were limited to studying the few upper kilometres of the crust that were accessible by mines or deep drilling. The different starting-points and procedures led to some divergence of goals and theories in the course of the twentieth century.

However, both geologists and geophysicists obviously have a common interest in studying the Earth. And, to a considerable extent, it was work in geophysics that led to the great change in ways of thinking about the Earth that occurred in the 1960s and '70s in the so-called plate tectonics revolution. Moreover, geophysical investigation came to be increasingly useful in small-scale investigations of local areas, as in seismic stratigraphy and in various kinds of prospecting. Therefore the term *Earth Science*, was adopted and commonly accepted to re-unite and gather together the main, as well as the subsidiary, disciplines of geoscience into one family; and many former academic departments changed their names at about that time from "Geology" to "Earth Sciences," or variants or different combinations of such terms. Earth Science (also known as geoscience, the geosciences, or the Earth Sciences), is, then, an all-embracing term for the sciences related to the Earth. It deploys mathematics, meteorology, chemistry, crystallography, cartography, geodesy, geography/geomorphology, biology, etc., in a combined field of study engaged in trying to understand the Earth's structure, origin, and behavior, etc. Needless to say, this does not mean that old sub-disciplines (e.g. ammonitology) have disappeared, will disappear, or are unimportant. On the contrary, they continue and will continue to develop, in accordance with the changes and needs of science and civilization. At the same time, we see the present development of formerly little-known disciplines such as geoelectrics and geothermics.

While there are numerous publications on the history of geology, the literature on the history of geophysics is limited, and one cannot point to any single book that seeks to give a general account of the history of its field(s). Yet geophysics (in its different branches) plays an ever-increasing role in Earth science. This being so, there is need for more detailed studies of the histories of the several branches of geophysics and their relationship to geoscience. The present papers are, therefore, offered as a contribution to this end, with the hope that they may be a useful prolegomenon towards the publication of wider synthetic studies of the history of geophysics (and Earth science more generally).

REFERENCE

R. L. Bates and J. A. Jackson (eds). 1997. *Glossary of Geology* (2nd edition). Falls Church, Virginia: American Geological Institute.